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FIAT PANIS

FOOD AND AGRICULTURE ORGANIZATION
REGIONAL OFFICE FOR ASIA AND THE FAR EAST
BANGKOK THAILAND

The Joint Meeting of the Working Party on Rice Breeding, the Working Party on Fertilizers and the Ad Hoc Working Group on Soil-Water-Plant Relationships of the International Rice Commission will be held in Vercelli, Italy, 23-28 September 1957 at the kind invitation of the Government of Italy. Letters of invitation have been despatched to all member governments concerned to send delegates to attend the meeting. The following is the Provisional Agenda:

PROVISIONAL AGENDA

Procedural Matters

1. Opening of the Meeting.
2. Election of Chairman and Vice-Chairmen.
3. Adoption of Agenda.

Matters Relating to Rice Breeding

4. Reports from Countries on Progress in Rice Breeding since the Last Meeting of the Working Party on Rice Breeding.
5. Reports of Follow-up of the International Rice Hybridization Project.
6. Maintenance of Genetic Stocks of Rice.
7. Milling and Cooking Qualities of Rice and Methods for their Determination.
8. Production and Distribution of High-Quality Seed of Improved Rice Varieties.
9. Establishment or Development of National Seed Improvement Organizations and possible Inter-Country Cooperation on Seed Improvement.

(Continued inside back cover)

LAND REFORM AND OTHER FACTORS CONTRIBUTING TO RICE PRODUCTION INCREASE IN TAIWAN

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RICE is the most important crop of Taiwan, for in addition to being the staple food of the local populace, it is the second largest earner of foreign exchange, has by far the largest acreage among all crops, and its price constitutes the backbone of the whole price structure. Since the termination of the Second World War, rural reconstruction has become the central part of the economic development program of Taiwan; and to increase rice production has always been a primary objective of the agricultural program. The success of the efforts made toward boosting rice production is borne out by the fact that the acreage, production, and yield per hectare of rice in Taiwan in postwar years have all exceeded their respective prewar records.

Table 1. Acreage, Production and Yield of Rice in Taiwan

Year	*Acreage* ha.	*Production* M.T. (Brown rice)	*Yield per ha.* kg. (Brown rice)
1935-1939 av.	653,878	1,339,494	2,052
Prewar record	681,548 (1936)	1,402,414 (1938)	2,242 (1938)
1945	502,018	638,828	1,273
1946	564,016	894,021	1,585
1947	677,557	999,012	1,474
1948	*717,744*	1,068,421	1,489
1949	747,675	1,214,523	1,624
1950	770,262	*1,421,486*	1,845
1951	789,075	1,484,792	1,882
1952	785,729	1,570,115	1,998
1953	778,384	1,641,557	2,109
1954	776,660	1,695,106	2,183
1955	750,739	1,614,953	2,151
1956	783,629	1,789,829	*2,284*

From Table 1 we can see that there was a rapid increase of rice acreage from 1945 to 1948. Thus in 1948, only three years after the war ended, the rice acreage had already surpassed the prewar record acreage. Such rapid expansion of area was

brought about by a sharp increase in demand for rice at that time. Not only did the sudden influx of population from Mainland China impose a heavy demand on local rice supply, but the local population, once freed from colonial and wartime restrictions, showed a marked tendency to eat more rice. The yield per hectare of rice during those years was, however, very low, as a result of the disrepair of irrigation facilities, the lack of chemical fertilizers, the disruption of supply of improved seeds, etc. By 1951, the expansion of rice area had reached an all time high of 789,075 hectares, being about 100,000 hectares more than the prewar record. Such expansion of rice acreage has apparently brought some of the rice fields on to marginal lands, notably those without reliable irrigation facilities. The frequency of drought hazards in these areas and the low production therefrom account at least partly for the rather slow recovery of the island's average per hectare yield of rice, notwithstanding the significant technical improvements made in other phases of rice production.

The yield per hectare of rice began to increase more sharply after 1949 and the increase has continued ever since. By 1956, it eventually surpassed the highest prewar record. The total rice production surpassed the prewar record as early as 1950, and continued to climb in the following years although the acreage has remained static after 1951. It may be said that from 1945 to 1948, the increase in rice production in Taiwan was due to the expansion of planting areas; from 1949 to 1951, it was due to the increase of both acreage and yield, and from 1951 to 1956, it was solely due to the continuous rise of yield per hectare.

Such steady improvement is due to many interrelated factors, e.g. the improvement of irrigation, the increase of the use of chemical fertilizer, the rehabilitation of the seed multiplication system, the improvement of pest control methods and cultural practices. All these factors are interrelated, additive, and mutually complementary. It is difficult to tell exactly which factor contributed most. But if each of the above mentioned factors is a pearl, the land reform is thread of silk which strings the pearls together to form an impressive necklace.

The aim of this article is to summarize briefly the manner in which these various factors have contributed to the increase of rice production, and the efforts currently made for further improvement. More detailed accounts of these subjects are given in other papers appearing in this same issue.

1. Land Reform

The land reform program in Taiwan was carried out in three different phases: The first phase involved reduction of the land rental paid by tenant farmers to land owners from a customary 50 percent or more to 37.5 percent or less of the value of the crop. The land rent reduction program was inaugurated in 1949, with the primary objective of improving the living of the tenant farmers and discouraging the holding of land by big

landlords, thus setting the stage for sale of land by the latter to the former in later years. 302,277 farm families signed 396,002 new contracts with land owners under this program involving 256,948 hectares of land. The second phase was related to the sale of the public land by the Government in 1951 at a price equivalent to 250 percent of the value of the main crop yields payable in ten years by semi-annual installments. At the end of 1953, 63,021 hectares of public lands had been sold to a total of 121,953 farm families. This phase of the program further served to elevate the social status of the tenant farmers and made it clear to every one, including the big land owners, the determination and sincerity of the Government to help tenants own the land which they till. The third and final phase of the land-to-the tiller program was authorized by the Government early in 1953 and completed in one year's time. Under this program, the Government bought land from absentee land holders and distribute it to tenant farmers. 70 percent of the payment to land owners by the Government was made in the form of interest bearing land bonds redeemable in ten years, and 30 percent in stocks of Government owned corporations which manufacture cement, paper and pulp and textile; and process agricultural products and others. The resale price of the land to tenant farmers was calculated on the basis of 250 percent of the value of the annual main crops payable in 20 semi-annual installments in kind. Before the price was fully paid, an interest of 4 percent per annum was payable by the new owners on the outstanding portion of land price. Up to the end of 1953, a total of 143,568 hectares had been purchased and resold by the Government to 194,823 tenant families.

The land reform program is at present almost completed. Before it was started in 1949, 38 percent of the total privately owned farm land was under tenancy. After the reform, the area under tenancy was reduced to 14 percent of the total private farm land. By 1955, the number of owner-farmer families in Taiwan had increased to 56 percent of the total number of farm families in the province, and the number of tenant families and farm hands had dropped to 17 percent and 5 percent respectively, the remaining 22 percent being part-owner-farmer families.

The effect of the land reform on the agricultural improvement program cannot be measured quantitatively. More important than any statistical figures can express, the successful implementation of the program has given the farmers a stimulus to improve their crop, their home and their living. The agricultural extension workers have been aware of such spiritual enlightenment on the part of the tenant farmers, reflected by the eagerness with which they adopt better seeds, insecticides, implements, cultural methods and more fertilizers; and solicit Government assistance in improvement of irrigation and drainage.

Equally important in an intangible way, the land refom program has won for the Government and its workers the confidence of the farmers. The simple logic is that a Government which helps farmers obtain

land has no reason to teach them wrong methods in farming. If farmers' lack of genuine interest for making improvement and their lack of confidence in agricultural extension workers are the two greatest obstacles to a successful agricultural extension program, the land reform removed both of them in one stroke. It is not a mere coincidence that the per hectare yield of rice started to rise steadily since 1949, the year when the first phase of land reform was initiated.

2. Seed Improvement

One of the earliest efforts made in Taiwan after the War in rice improvement was to strengthen the rice breeding and rehabilitate the rice seed multiplication system. Achievement in breeding is evidenced by the gradual waning in popularity of the variety "Taichung 65" in recent years. In 1941, this variety alone occupied more than 65 percent of the total area of Ponlai (*Japonica* type) rice in both spring and fall planted crops. In 1956, its area dropped to 25 percent, being replaced gradually by new Ponlai varieties developed after the War. The rice seed multiplication system not only enabled the growers of the Ponlai varieties to renew their seeds once in every three crops, but also made it possible for the acreage of Ponlai rice to expand continuously. By 1956, it reached an all time high of 450,000 hectares, comprising 57 percent of the total Ponlai acreage. Since under favourable conditions, Ponlai varieties yield from 10 to 20 percent higher than native *Indica* varieties, it is natural that the expansion of Ponlai rice acreage will result in an increase in the average rice yield.

3. Use of Chemical Fertilizers and Manure

The gradual increase in the use of chemical fertilizers on rice in postwar years is shown in the following table:

Table 2. Rates of Chemical Fertilizers (in Term of Nutrient Elements) Allocated per Hectare of Rice in Taiwan

Year	*Per hectare allocation rate (kg.)*		
	N	P_2O_5	K_2O
1937-1939 av.	70.0	24.6	7.9
Prewar record for N (1938)	77.8	(21.7)	(5.7)
1945	0.3	0.6	0.2
1946	1.5	–	–
1947	13.8	9.5	–
1948	17.6	6.3	–
1949	23.3	7.8	–
1950	51.6	14.0	–
1951	58.6	11.8	7.3

Year	*Per hectare allocation rate (kg.)*		
	N	P_2O_5	K_2O
1952	65.9	24.1	9.8
1953	67.0	27.6	11.1
1954	83.4[1]	29 2	12.0
1955	83.5[1]	33.3	13.8
1956	85.3[1]	33.7	14.3
Optimum rate based on experiments:	80.0	40.0	40.0

It can be seen from the above table that the present rate of application of chemical fertilizers on rice has surpassed the maximum rate applied before the war. The rate of nitrogen has already reached the optimum, though that of phosphorus and potassium still has some room for increase.

The Government also encouraged the use of compost manure on rice and other crops. Since 1949, cement has been provided to farmers as a subsidy toward the building of compost shelters, with farmers themselves paying for other building materials and labour cost. From 1949 to 1956, a total of 102,027 compost shelters were built by farmers with such subsidy. It is estimated that 2,500,000 M.T. of compost manure are produced yearly from these shelters. The total annual production of compost manure of Taiwan is around 7,000,000 M.T., the bulk of which is being used in rice fields. The farmers generally apply 6,000 kg. of compost manure to each hectare of spring planted rice, and 4,000 kg. for the fall planted rice. The recommendation of the Government is to use up to 9,000 kg. per hectare per crop. The compost is made mostly of rice straw, sugarcane leaves, other plant refuse and hog manure.

Sesbania sesban is the most widely grown green manure crop in rice fields, especially as a winter crop in South Taiwan. Soybean and field pea are also grown to some extent in the southern and central Taiwan, respectively, for both picking the pod and green manuring. But until recently, there had been no suitable leguminous green manure crop to recommend for the northern Taiwan, because the wet and cool winter there prevents most green manure crops from making a satisfactory growth during the period between the harvest of the fall rice in November and the transplanting of spring rice in March. Since 1955, however, experiments on *Astragalus* planted two weeks to 20 days before the harvesting of the fall rice crop have yielded an average of 20,000 kg. of green stuff per hectare. It is expected that the planting of *Astragalus* in North Taiwan as a paddy field winter green manure crop will spread rapidly, and will

1 The optimum rate of application (80 kg. N per ha.) is the rate at which the increase in crop yield per additional unit of fertilizer applied is the largest. However, in the consideration of increasing rice production of the Island as a whole, application up to 120 kg. nitrogen per hectare is still profitable.

help increase the rice yield over some 100,000 hectares of land in this area.

4. Pest Control

The contribution of pest control to the increase of rice production in recent years in Taiwan is prominent. The acceptance of new pesticides by the farmers is especially noteworthy. Since the introduction of the first litre of parathion (Folidol E-605) for testing in 1952, the use of parathion and other organo-phosphorous compounds for the control of rice borer has quickly been established in rural Taiwan as a routine practice in rice culture. For the fall rice crop of 1955 and the spring crop of 1956, 45,000 litres of parathion were bought by farmers and applied over some 65,000 hectares of rice. Hence three private factories were set up during the last year to manufacture pesticides of the organo-phosphoric and chlorinated hydrocarbon groups from imported materials. A fourth factory, owned by the Government, has added the making of these modern pesticides to its original business of manufacturing DDT and BHC. Since 1956, the control of rice insects has become completely commercialized, with farmers buying their own sprayers and pesticides.

3,360 M.T. of locally made 1 or 1.5 percent BHC powder were used during the fall of 1955 and the spring of 1956 over 113,000 hectares of rice field for the control of other rice insects. Another even more widely practised measure is the soaking of rice seed before planting in 0.1 percent solution of organic mercury compounds for the control of rice diseases. Annually, 100,000 lbs. of these compounds were used up by farmers in Taiwan for treating seeds covering about 287,000 hectares of rice fields.

5. Improvement of Farm Machinery

Many types of farm implements and machines are used in Taiwan for rice production, but mostly have been in use for many years. Significant developments which have definitely contributed or will most certainly contribute to the increase of rice production in Taiwan are enumerated below:

(1) Before 1953, there was only one government operated pilot plant which turned out sprayers on an experimental basis. Sprayers and dusters used before this were mostly imported from Japan, and the number imported was small, as chemical spraying for control of rice insects and diseases was not widely practised. Since the successful demonstration and extension of the use of parathion and Endrin for the control of rice borers, the demand for sprayers suddenly increased. During the past three years, more than a dozen private factories have been established to manufacture sprayers and dusters, including some power sprayers. Rice growers are now buying more than 10,000 sprayers a year.

(2) Introduction, experimentation and demonstration of small power tillers has been undertaken during the past three years. The progrom was prompted by the shortage

of an estimated 100,000 head of draft cattle in Taiwan in the face of expanding cultivated land area and tight crop rotation schedules. Extensive experimentation on the performance and the cost of operation of 2.5 HP to 3.5 HP tractive and rotary type power tillers has demonstrated that this type of machine would be a good substitute for water buffaloes in Taiwan.

6. Expansion and Improvement of Irrigation Facilities

Although Table 1 shows that there has been no increase in rice acreage in Taiwan after 1951, it does not mean that the effort to improve irrigation facilities has stopped, as may be seen from Table 3.

Table 3. Areas of New Irrigation and Improved Irrigation[1]

Year	*Area of land with new irrigation facilities*	*Area of land with improved irrigation*
	ha.	ha.
1953	11,753	7,425
1954	7,336	49,858
1955	7,298	36,144
1956	7,369	23,658

This means that while on one hand new lands have been brought under irrigation each year, and the irrigation on some lands has been made more dependable; on the other hand some marginal lands have been retired from rice production. In one southern area (Tainan), the extension of a special cultural system developed for planting sugarcane on heavy-clay, rain-fed single-crop rice field has met with some success. In a northern area (Miaoli), a new variety of soybean has produced more than a poor crop of fall planted rice in rain-fed fields. The area under this soybean variety is expected to increase rapidly in North and East Taiwan in the near future where irrigation facilities are lacking.

It is now obvious that, although the rice planting area of Taiwan has not increased since 1951, there has been a steady improvement in irrigation facilities thereby contributing definitely to the increase of rice per hectare yield in recent years. In addition, the provision of better irrigation enables farmers to change from the planting of native rice varieties to the higher yielding Ponlai varieties, to make more efficient use of chemical fertilizers, and to further increase the double cropping index of the land.

7. Prospects of Further Rice Production Increase

The population of Taiwan is at present about ten millions; and the rate of increase

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[1] *Area given here is in term of crop area, i.e., if a one-hectare piece of land is planted twice in a year, it is counted as two hectares.*

is over 3 percent, or more than 300,000 persons per annum. The present rice consumption is about 150 kg. of brown rice per capita per year. Therefore 45,000 more metric tons of rice is needed each year for feeding the increased population. At the present hectare yield, 20,000 additional hectares of land is needed each year for growing the needed additional 45,000 M.T. of rice. Since available arable land is limited, further raising the yield per hectare is not only feasible, but imperative. Under the Second Four-Year Plan for Economic Development of Taiwam, it it planned that by 1960 the rice acreage will be increased to 830,000 hectares, yield per hectare to 2,470 kg. brown rice per hectare per crop, and the total production to 2,050,000 metric tons of brown rice. The following are some of the technical aspects of the plan to reach these goals:

(1) Seed improvement – The future aim of rice breeding is to develop new Ponlai varieties (*Japonica* type) with an even earlier maturity than the present ones to facilitate rotation with winter crops; resistant to rice blast to stabilize the yield; and better quality to enhance its commercial value. Field inspection of seed farms will be strengthened and laboratory seed analysis installed in the near future.

(2) More efficient use of chemical fertilizers – The per hectare rate of chemical fertilizer application is not expected to make any substantial gain in the future. The efficiency in the use of chemical fertilizers on rice in some areas, however, will improve, following the further improvement in irrigation (e.g. Shihmen Dam) and soil property. The latter will be made possible by the extension of new green manure crops or the use of more other organic manure (e.g. compost, filter cakes from sugar mills, etc.). Thus far, chemical fertilizers have been allocated to rice farms at fixed amounts for each hectare. The accumulated data on soil and fertilizer studies are not yet sufficient to provide a basis for recommending the rates of chemical fertilizer application to individual farms. Soil testing methods are being studied. It is hoped that practical means may soon be developed to determine the fertilizer needs of individual farms. The present allocation system should give way to free marketing; the bulk of the chemical fertilizers consumed must be supplied by local industries which market their own products to farmers; and the farmers must be sufficiently educated to appreciate the value of using proper rate of fertilizers adapted to the soil conditions of their own farms. Such objectives, however, may not be fully realized in the immediate future.

(3) Field rodent and granary pest control – After two years of laboratory and field studies, various methods of controlling field rats have been tested. It has been found that baits made of 0.5 kg. of 0.5% Warfarin, 9.5 kg. brown rice, traces of peanut oil, sugar and salt, and deposited in bamboo stations placed at the rate of 15 to a hectare in winter when the food in the field is scarce, have proved effective in destroying nearly all the rats in the baited area. From the result of demonstrations carried out in 14 townships last year, it was estimat-

ed that there were 40 million rats on this Island which would annually consume up to 200,000 M.T. of food. An island-wide baiting campaign for rat eradication will be conducted in the winter of 1957 and the early spring of 1958. This campaign is expected to bring significant reduction in the loss of rice. The next step to further reduce the loss of rice would be the granary pest control. Experimental data have been accumulated, demonstrations on a limited scale have been conducted and an extension program is being planned for after the completion of the rat control campaign.

(4) Extension of small power tillers — Long range planning for the extension of the small power tillers includes giving encouragement to local factories not only to manufacture similar machines, but to improve and modify the attachments so that they will be better adapted to local needs; training technicians and extension workers who in turn will educate and service the farmers; and arranging for stable fuel supplies; and providing credit to help farmers buy the tillers. These preparatory works are being undertaken.

(5) Further improvement of irrigation - According to the estimate of hydraulic engineers, there are yet 60,000 hectares of dryland in Taiwan which could be turned into double rice crop field, and 60,000 hectares into single rice crop field; in addition, there are also 100,000 hectares of single rice crop fields which could be turned into double crop rice fields by construction of new irrigation projects or by improvement of the existing systems of irrigation. However irrigation projects of lower cost and easier engineering have been mostly completed during the recent years. For further development, the engineering aspects will become more and more difficult and the cost of construction higher and higher.

Such major projects as the Shihmen Reservoir and the systematic development of the under ground water resources in the southern Taiwan have already been started. The adoption of the rotational method of irrigation will contribute substantially to a fuller utilization of the water resources.

THE SYSTEM OF RICE SEED MULTIPLICATION AND EXTENSION IN TAIWAN

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1. Background

The sub-tropical climate of Taiwan plus a rather well-developed irrigation system make it possible to produce two crops of rice annually in most areas. Rice varieties in Taiwan fall into two broad groups, namely: the lowland and the upland rice. The lowland rice which accounts for 94 per-

cent of the total acreage can be further classified into three types, namely: Ponlai rice (*Japonica* type), native rice (*Indica* type) and glutinous rice (both *Japonica* and *Indica* types). Among the lowland rice, Ponlai rice acreage is the largest, accounting for 55 percent of the total lowland rice acreage; native rice ranks second, with an acreage amounting to 42 percent of the total; and the glutinous third, accounting for 3 percent. The Ponlai rice is, in fact, a common name for all the improved varieties, which were derived either from the intercrossing of the introduced Japanese varieties, or from the latter's crossing with the native rice varieties in Taiwan. It outyields the native rice by 10-20 percent and also has a better milling quality. Since its first introduction into Taiwan in 1922, its acreage has been expanding steadily, reaching 100,000 ha. in 1926, 200,000 ha. in 1933 and 450,000 ha. in 1956. As a result, the rice production of Taiwan has increased immensely. In 1921 it was slightly over 700,000 M.T. But in 1930 it topped 1 million M.T., in 1950 it reached 1.4 million M.T., and in 1956 1.8 million M.T., or 2.5 times the 1921 figures. One of the most important factors contributing to the success is the breeding, multiplication and extention of the improved rice varieties.

2. Seed Multiplication and Extension System

Seed rice is multiplied by three steps; the foundation seed, the stock seed and the extension seed. The general practice is to renew the seed once every three crop seasons. Since the same Ponlai rice can be grown both in the first and seecod season of the year, it takes only one and a half years to complete the renewal. The foundation seed farms are operated by seven district agricultural improvement stations, one for each of the seven rice producing regions of the Island. There are 160 stock seed farms, either run by local government organizations or by farmers' associations, but mostly by contract farmers; and about 4,000 extension seed farms, operated entirely by contract farmers, one farm for every village in the Island.

The acreage of land devoted to seed propagation and the amount of seed to be produced by the various seed farms in each crop season are determined by the amount required for seed renewal for 1/3 of the total acreage under Ponlai rice in the Island. The general guiding principle is that the seed produced from one unit of a foundation seed farm should be sufficient for planting 25 units of stock seed farms, and the production from one unit of stock seed farms for planting 40 units of extension seed farms. Thus the total acreage of seed farms required for the multiplication of the foundation, stock and extension seeds for each crop season is about 4 ha., 94 ha., and 3,750 ha. respectively. The average size of a seed farm is around 0.5 ha.

The foundation seeds are distributed to the stock seed farms free, while the stock seeds are purchased by different county or municipal governments and distributed to the extension seed farms free. The extension seeds are bartered for farmers' seeds either

at the ratio of 1:1, or at a premium up to 20 percent.

3. Management and Inspection of Seeds Farms

Care is required in the management of the seed farms at the different levels in order to ensure the purity and trueness of the rice plants to the variety characteristics. In foundation seed farms, the one plant per hill method is practised and the seedlings are transplanted in straight rows with regular intervals between rows and hills (24 cm. x 21 cm. on the average) to facilitate observations, operations, weeding and roguing. Every hill in the field is closely inspected. Four to five roguings are carried out from tillering to dough stage. The expected rate of seed production is set at a low level of 1,500 kg. per hectare, which is sufficient for planting 25 ha. of stock seed farms at the rate of 60 kg/ha. for Ponlai rice. The operation of stock and extension seed farms is similar to that of the foundation seed farms except that four to six plants are transplanted per hill and the roguing is done three to four times in each crop. The expected yield of rice from the stock and extension seed farms is no less than 2,400 kg./ha. Each hectare of the extension seed farms should produce enough seed for planting 40 hectares of rice fields in the following crop season.

The foundation seed farms are under the care of the rice breeders of the district agricultural improvement stations, while the stock and extension seed farms are supervised by the technicians from township offices during heading and dough stages. If a mixture is found, it must be removed before the field can be accepted. Blast infection must be less than 5 percent. Such other factors as heading, grain uniformity and ripening conditions are also closely checked.

4. The Role Played by Extension Seed Growers in the Whole System

From the above discussion, it can be seen that rice seed is largely multiplied by the contract farmers. If it were not for the active participation of these individual growers, it would have been impossible to carry out the system of seed multiplication and extension in Taiwan on such an extensive scale. The extension seed grower must be a member of a local farmers' association and a farm operator owning a farm of not less than 0.7 ha., with some education, having years of experience in rice culture and enjoying good reputation in his own district. The location of his farm should not be far away from a highway. Once chosen by the township office, the farmer usually carries on the job of seed multiplication for several years. It is not unusual to find a seed grower with ten to fifteen years of service record. Their farms are well managed and they take pains to keep the field crop pure and true to the variety characteristics. No doubt, they have to put in additional labour

Some of them may get it paid for by collecting 10-20 percent premium in the bartering of pure seeds for ordinary ones. Most of them, however, refuse to accept the premium for the reason that the other farmers to whom the seed is sold are either their relatives or friends and it would appear to them improper to make a profit out of the deal. Most of them, therefore, operate the seed farms on a non-profit basis.

The interested government agencies have tried to keep up the spirit of these volunteer seed farmers by all possible means, such as distributing to them free posters, pamphlets and other publications concerning rice and agricultural improvement and holding contests on the management of extension seed farms. Certificates and prizes are awarded to the winners. Winners of the first prize in local districts may be given free tickets to go to Taipei on the Farmers' Day to attend a reception given by the Commissioner of the Department of Agriculture and Forestry or some other high official of the provincial government. Besides, the Department, during the past six years with the assistance of the Joint Commission on Rural Reconstruction, has appropriated a large sum of money to help seed growers construct 6,110 concrete drying floors, 971 bowl-type storage huts, and 783 metal bins. Most of the seed growers have received free radio sets and cash subsidies for the up-keep of their compost shelters.

5. The Organization and Operation of the Seed Multiplication System

Varieties to be multiplied and the amount of seed produced are first decided upon in township meetings at which village chiefs, small unit chiefs, directors of township farmers' associations, seed growers, and township officers all participate. The decision reached is then referred to the county and provincial meetings for approval. It is the policy of the government to limit the number of improved varieties planted in any one region to not more than four or five in order to facilitate the maintenance of seed purity. The total number of improved varieties multiplied in 1957 in Taiwan is 21. The meetings at the different organizational levels are held twice a year, before the planting of a rice crop. The provincial meeting also passes its final judgement on the kind or kinds of materials to be used in the province-wide tests, district-wide tests, as well as in variety demonstration plots.

The over-all plan prepared by the Provincial Departments of Agriculture and Forestry covers not only the acreage to be planted for the year but also the amount of seed to be produced for each variety at each type of seed farms. Aftet being adopted, the plan is further detailed to indicate the exact resposibilities of the county and township governments and the individual seed growers.

6. Conclusion

The rice seed multiplication and extension system was established thirtyfive years

ago. In the early stage emphasis was placed on getting more seed growers but little was done to establish the seed farms. Before the outbreak of World War II, only the seven foundation seed farms operated by the government and six stock seed farms run by the farmers' associations were provided with the necessary facilities, while all the extension seed farms were sadly neglected. As a result of the War, the acreage under Ponlai rice dropped from the prewar record of 400,855 ha. to 196,036 ha. in 1946.

After the War, the Provincial Department of Agriculture and Forestry took vigorous steps to revitalize the whole system of seed multiplication and extension, with the financial and technical assistance of the Joint Commission on Rural Roconstruction. It provides the necessary leadership, together with travel expenses and transportation facilities for its supervisors. In the meantime, it gives encouragement to all the individual seed growers as mentioned before. As a result of several years of continous effort, Ponlai rice seed is now multiplied in sufficient quantities in each crop season for seed renewal on 150,000 hectares, or 1/3 of its present acreage.

Since Ponlai rice outyields the native rice by 10-20 percent, the expansion of its acreage is an important factor contributing to the steady rise in hectare yield in Taiwan.

FERTILIZER USE IN RICE PRODUCTION IN TAIWAN

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1. Economic Significance of Fertilizer Use in Rice Production

Rice production plays a most important role in the economy of Taiwan. The total planting acreage of both the spring and fall crops of rice reached 783,629 ha. in 1956, producing 1,789,829 M. T. of brown rice at the average yield of 2,284 kgs. per hectare per crop. Not less than three million people, representing about 33 percent of the Island population, are directly engaged in rice growing. Rice not only supports about ten million people but also is the second important item on the list of export of Taiwan products.

Rice production in Taiwan depends heavily on fertilizer use. In recent years more than 400,000 M. T. of chemical fertilizers were annually used for this crop. It consumes about 80 percent of all the fertili-

zers used in the Island. Nearly 20 million U.S. dollars was spent in 1956 for importing chemical fertilizers for rice production. Approximately 600 kgs. of fertilizers is now applied to each hectare of paddy field and constitutes about 20 percent of the total production cost. Either from the viewpoint of the national economy or the farmers' economy, the efficient use of chemical fertilizers is of paramount importance in rice production.

2. Effects of Fertilizers on Rice Production

Chemical fertilizer has been used on rice in Taiwan for more than thirty years. In 1938, the total quantity of fertilizers used for rice production was 389,334 M.T. and the yield of brown rice per ha. was 2,242 kgs. But in 1945, on account of World War II, the fertilizer consumption on rice dropped to 1,958 M.T., and the yield also decreased to 1,273 kgs./ha. Taking the period of 1935-39 as peak years when the average annual consumption of fertilizers on rice was 359,433 M.T., and 1944-48 as lean years when the average was 41,308 M.T., the comparison between the two periods reveals that the average annual production of brown rice had dropped from 1,339,494 M.T. to 933,641 M.T., and that the average yield per ha of 1944-48 was 26 percent less than that of 1936-39.

From the field experiments, the comparison between the continuous application of NPK fertilizers for 24 years and no fertilizer use is 2,581 kgs./ha. against 1,117 kgs./ha., for the first crop of Ponlai rice, a reduction of 56.7 percent of the yield due to non–use of fertilizers.

The results of the rice fertilizer experiments conducted in more than hundred localities show that, by applying nitrogen up to 120 kgs./ha., the yield can be profitably increased. Taking 120 kgs./ha. of nitrogen as a standard rate of application, 8.7 to 10.2 kgs. of paddy for the first crop can be increased by each kg. of nitrogen added, and 6.1 to 7.1 kgs. for the second crop, the percentage of increased production being 37-57 percent and 29-34 percent, respectively. Phosphate and potash fertilizers have little responses in rice production. However, in some particular areas, a fairly good effect from these fertilizers is significantly shown, especially when potash fertilizer is applied to the second crop.

A summary of data and response curves for the first crop of rice is shown below:

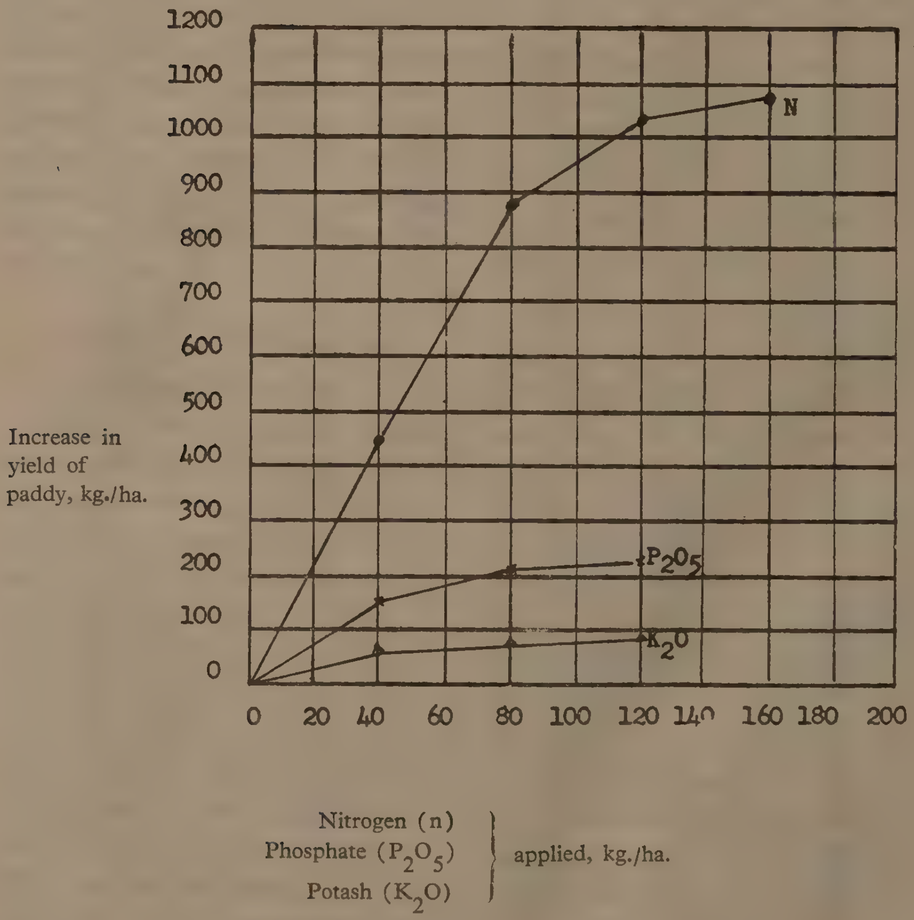
Table 1. Average Results of Fertilizer Experiments Conducted in 104 Localities from 1929-1942, Taiwan, China

(Limited to 1st crop each year and paddy yields and fertilizers applied all in kgs./ha.)

Fertilizer treatment	Nutrient level	Control yield	Nutrient level	Yield	Increase over control	Nutrient level	Yield	Increase over control	Nutrient level	Yield	Increase over control	Nutrient level	Yield	Increase over control
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
N with adequate P_2O_5 and K_2O (80 kgs/ha. each)	0	2,848	40	3,291	443	80	3,719	871	120	3,889	1,041	160	3,923	1,075
P_2O_5 with adequate N and K_2O (80 kgs/ha. each)	0	3,512	40	3,668	156	80	3,719	207	120	3,738	226			
K_2O with adequate N and P_2O_5 (80 kgs/ha. each)	0	3,632	40	3,716	84	80	3,719	87	120	3,723	91			

Note: The Columns 1, 3, 6, 9, 12 under nutrient level indicate the rate of N, P_2O_5 or K_2O applied in kgs./ha.

Chart 1. Graphic Representation of the Data Presented in Table 1



3. Recent Efforts Made to Increase the Efficient Use of Fertilizers

Although the use of chemical fertilizers has become very popular among the farmers of Taiwan, misconception and misapplications are not uncommon. For instance, rice farmers are not thoroughly acquainted with the use of balanced N-P-K, the three major elements required for crop growth. They take it for granted that all chemical fertilizers should turn leaves green as ammonium sulphate does. Any fertilizer that has no such visible effects is considered poor. Therefore, farmers are much less ready to accept the use of phosphate and potast fertilizers. If phosphate and potash fertilizers are used,

they are always applied as top dressing instead of as a base manure. In order to disseminate knowledge on the most efficient use of fertilizers, the Provincial Food Bureau and Provincial Department of Agriculture and Forestry, with the techncial and financial assistance of the Joint Commission on Rural Reconstruction, have been carrying on an islandwide program of fertilizer education and demonstration since 1951. The main activities in this program are outlined as follows:

(1) Holding training classes on fertilizer application

Training classes are held in each township to educate the farmers on the proper application of fertilizers. During the period of fertilizer distribution, discussion meetings are held for the village chiefs, who are informed about the characteristics of the various kinds of fertilizers, their methods of application, and the procedure of their distribution, and are requested to transmit this information to the farmers.

(2) Setting up fertilizer demonstration farms

Field demonstrations on the effectiveness of fertilizer use and methods of application are planned by the provincial agencies and supervised by the township farmers' associations. Farmers in the neighbourhood are invited to see the demonstration plots twice in the rice growing and harvesting periods. More than a thousand demonstrations are conducted over the whole Island for each crop of rice.

(3) Publicity through radio and other means

The Provincial Food Bureau, which handles fertilizer distribution, prepares articles in simple language on the methods of fertilizer application and the procedure of their distribution and sends them out through the Provincial Information Office to all broadcasting stations in the province for publicity through its radio program. The same material is also sent to the Harvest, a bi-weekly farmers' journal published by JCRR and widely circulated among farmers, for publication. The local Food Offices also conduct publicity campaings by sending trucks equipped with loud-speakers to the villages at proper times to remind farmers of the timely procurement of fertilizers and the proper methods of fertilization.

(4) Other educational means

In taking deliveries of fertilizers from the warehouses of the farmers' association, farmers usually have to wait for some time to complete the delivery procedure. The farmers' association staff always takes advantage of such leisure hours to educate the farmers on the spot, regarding the names, characteristics, and methods of application of the fertilizers distributed.

Through all these educational methods, remarkable progress has been made on the wise use of the three major fertilizer nutrients for rice production. Along with other phases of agricultural improvement, the use of chemical fertilizers has made a significant contribution towards the continuous increase in rice yield, as indicated in the table below.

Table 2. Consumption of Fertilizer Nutrients for Rice Crops

	N		*P_2O_5*		*K_2O*		*Yield of brown rice*	
	Kg./ha.	*Index*	*Kg./ha.*	*Index*	*Kg./ha.*	*Index*	*Kg./ha.*	*Index*
1951	58	100	12	100	7	100	1,882	100
1952	66	114	24	200	10	243	1,998	106
1953	67	116	28	233	11	157	2,109	112
1954	83	143	29	242	12	171	2,183	116
1955	83	143	33	275	14	200	2,151[1]	114

4. Experiment and Research Work on Fertilizer Use for Rice

Two kinds of fertilizer research are now being undertaken by the Taiwan Agricultural Research Institute: Fertility studies on paddy soils and field experiments.

In 1953 and 1955, 173 N-P-K fertilizer experiments of rice with 3×3×3 confounding design were conducted in various places according to the main soil groups of Taiwan. The results obtained show that for all soil groups, nitrogen has the most response. An application of 80-120 kgs. of N per hectare for the first crop and 60-80 kgs. of N per ha. for the second crop is recommended. The alluvial soil originated from sandstone and shale or slate always gives more significant response than the latosol. Most Taiwan soils as a result of the manuring system, are not seriously deficient in phosphorus and potash. However, on the lateritic soil, the two nutrients, P_2O_5 and K_2O, have more significant response than on other soils. The general recommendation for them is 40 kgs./ha. each.

Calcium ammonium nitrate (nitrochalk) and urea will soon be manufactured in quantities in Taiwan. Methods of applying them on paddy have been studied. The response of rice to nitrochalk applied as a base manure is decidedly inferior to ammonium sulphate. Late applications for nitrochalk as a top dressing may raise the paddy yield more than its application as a base manure. Better results, however, may be obtained by supplying one-half or one-third of nitrogen from ammonium sulphate as a base manure and the rest from nitrochalk as top dressing. The nitrochalk is applied about 40 to 60 days after tranplanting the first rice crop and 30 to 50 days after transplanting the second crop.

When urea is to be used as a base manure on paddy land, a thorough mixing with the surface soil is advisable. In the soils of light texture, the field should be drained before application. Flooding three or four days after application appears to be profitable. Urea also can be applied once or twice as top dressing prior to weeding.

The relative availability of superphosphate, fused phosphate and Reno rock phosphate was tested on some representative soils, including lateritic soils, slate alluvial

1 Effect of the unusual drought in the first crop season.

soils and shale and sandstone alluvial soils. It was found that superphosphate is in general superior to the other two phosphate carriers in all kinds of soils. Fused phosphate and rock phosphate are much less available than superphosphate on neutral soils; while on acid soils, their availability is almost comparable to that of superphosphate.

Liming acid paddy soils was also tested. The experimental results reveal that the effect of lime on rice is related to the status of soil fertility. On very fertile soils or soils receiving sufficient fertilizers, the rice crop has not shown as much response to lime as on the infertile soils, or soils receiving only organic manures. Soils low in pH value, which are generally of poor fertility, usually have good response to lime. It is recommended that three tons per hectare of lime be applied to the first crop of rice as base dressing.

DISEASES AND INSECT PESTS OF RICE IN TAIWAN AND THEIR CONTROL

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A. Rice Diseases

Over 40 diseases of rice have been recorded in Taiwan. Among them, the blast, sheath and stem rots, the elongation disease, and the sesame leaf spot are common. Economically, the blast disease, which causes more damage than all other diseases combined is most important. Brief notes are given below on some of the more important diseases and some of the work that has been carried on in the past few years.

1. Rice Blast Piricularia oryzae

(1) Seasonal development and losses. The disease is most prevalent in the first rice crop and seldom bothers the second crop. It appears to be most destructive to the leaves at the tillering stage during late March through early May. A continuous rain during the heading stage (consequently lowering of the temperature) may also cause serious outbreaks of neck-rot. Fields below hills with cooler irrigation water are much more liable to the disease attack than those on the plain.

Damage from the disease in individual fields varies from a very slight to a complete loss. Acreage reported to suffer from severe attacks (over 50% loss) amounts to 40,000 to 50,000 hectares in the past few years. In 1953 and 1954, when a continuous rain occurred during the heading stage of the first crop, the neck-rot wiped out the crop almost completely in many thousands of hectares in the South. The annual loss due to the disease is estimated to be not less than 5% of the total rice crop.

(2) Sources of infection and the effect of environmental factors. While the disease is chiefly seed borne, wild hosts and the diseased refuse of the previous crop may also serve as sources of infection in Taiwan.

The disease is greatly affected by environmental factors. Relatively low temperature (average daily temperature 20-25°C) and high humidity favour its development. This is clearly indicated by the fact that the disease is much more serious in the first crop of rice than in the second in Taiwan and the fact that fields below hills with cooler irrigation water develop more disease. In many areas no susceptible varieties of rice can be planted in the first crop for the reason that the environmental factors favour the pisease development. It is also interesting to note that the disease is very destructive in the temperate zone, such as in Japan, less so in the sub-tropical countries and diminishes in intensity toward the tropics.

The disease is very sensitive to the application of fertilizers. The nitrogenous fertilizer favours its development especially when it is applied alone. Heavy applications of nitrogenous fertilizers (150 kgs. N per hectare) in fields near hill sides or in areas with cooler climate will always induce serious outbreaks of the disease. Under these conditions, susceptible varieties will be killed completely before heading. One may notice that the disease often develops in a corner of a field where a manure pit was located without spreading to the other parts of the field because of the nutritional differences. The level of nitrogenous fertilizers used may often determine the degree of the disease development.

(3) Chemical control. A program of seed treatment by soaking rice seed in a solution of organic mercury compound (1/20,000 active ingredient) was launched in 1950. Since the Ponlai rice is most susceptible, the program was started with it in the first crop. Now it has been extended to include native varieties and the second crop as well. Nearly 100,000 pounds of the chemicals are used annually. Treated seed are sufficient to plant over 300,000 hectares. Besides the large wooden tubs or earthen jars generally available on all farms, small brick and cement ponds are constructed for community use. The desired length of time for soaking the seed is 6 hours; however, for practical extension purposes, 1 hour is recommended.

Applications of chemicals in diseased fields have been introduced, especially of ceresan-lime dust which has proved to be very successful in Japan. However, the following problems will have to be solved: (a) time of application, (b) reduction of chemical injuries to native varieties, and (c) lowering the cost of application.

Spore trap stations were established in 1956 at various localities throughout the Island to determine the seasonal development or the dissemination of the spores. The accumulation of such information may help determine the proper time of applying fungicides.

(4) Varietal resistance. Generally speaking, the Ponlai rice is more susceptible

to the disease than the native rice. Nearly 1,000 varieties including both Ponlai and native types have been tested for their resistance to the blast disease in the past few years. The breeding stock varieties were tested in the green house for leaf blast with artificial inoculation, while the extension varieties were tested in the field to determine both the leaf and neck phases of the disease.

Of the varieties tested, over 170 show high degree of resistance. However, the resistance varies greatly from locality to locality. Most of the varieties that showed resistance in the northern and central part of the Island became susceptible in the South. Particularly noticeable is the variety Bai-ki-tou which was almost immune in all 3 testing stations in North and Central Taiwan, but became quite susceptible in the South. A collection of 40 varieties including the resistant, intermediate, and susceptible were planted in different stations from the North to the South to verify their resistance or susceptibility in 1956. The variation in resistance in the 4 localities is very evident in most of the varieties with the exception of a few most susceptible varieties.

The resistance of rice varieties to the blast also varies from year to year. This has been noticed in tests during the past few years and also with the older varieties, which showed resistance in the early years but become susceptible at present.

Among extension varieties, now considered more resistant are: Kwan-fu 1, Kaohsiung 22, Kaohsiung 27 and the newly developed Chia-nung-yu 242, Kaohsiung-yu 73 and Taichung 179 of the Ponlai group, and Pei-me-fen, Pei-ko-chu, Nee-kung-po and Tsai-yuan-chung and the newly developed Taichung Native 1 of the native type. The most common variety Taichung 65 (*japonica* type) is very susceptible.

(5) Breeding rice for blast disease resistance. Crosses between Ponlai and native varieties, resistant and susceptible, Ponlai and upland rice, and Ponlai and glutinous rice with a total of 30 combinations have been made since 1950 in the hope to develop resistant varieties of the Ponlai type with good qualities. Progenies were planted in testing fields where all the susceptible "check" varieties succumbed. Back crosses were made to the variety Taichung 65 which is a very good variety except that it is susceptible to blast. Up to now 12 varieties have been selected for the advance test, 70 - 80 lines in homozygous state with desirable characters, over 350 lines in F_5 to F_7 generations for further observations and back crossing. Taichung 171 and 179 were once intended for release. Further tests, however, showed that the two varieties varied in their resistance from year to year in the same locality, as well as in different localities. Available data are insufficient to indicate as to whether this is due to different physiologic races of the fungus, the effect of environmental conditions, or some other reasons. Studies on the physiological races of the fungus were started in 1957.

2. Banded Sclerotial Disease

A group of sclerotia-forming fungi attack rice. Among them, *Corticium sasakii*

(Sharai) Matsu, *Rhizoctonia oryzae* Ryker et Gooch, *Helminthosporium sigmoideum* Cov. var. *irregulare* Cralley et Tullis, are more common, particularly *C. sasakii* which is often referred to as banded sclerotial disease, and has been reported to cause serious damage in the past two years in the south of the Island.

The disease is more common during the second crop season when the temperature is high. It appears first in the field as scattered spots which gradually increase to large areas. The affected plants show large, pale brown, or grayish lesions with undulate, well defined margin on the leaf-sheaths. These plants often become blighted before they reach maturity, or the ears do not fill well. Hot weather and abundance of nitrogenous fertilizers favour the development of the disease.

The small sclerotia of the fungus survive in stubble and float on irrigation water. These sclerotia spread the disease from crop to crop and from field to field.

Chemical control of the disease has been tried without success. Varietal differences in resistance to the disease have also been noticed, but no difinite conclusion can be made at the moment.

3. Helminthosporium Leaf Spot

Leaf spot caused by *Cochiobolus miyabeanus* (Ito et Kur.) Dickson is very common in Taiwan. However, severe damage has seldom occurred under normal conditions.

Fertilizers are reported to affect the development of the disease as well as the type of lesions. More numerous small lesions are developed in fields where the application of nitrogenous fertilizers is low. This is in contrast to blast disease which is favoured by nitrogenous fertilizers. The individual lesions may become larger in fields where potassium is insufficient.

Varieties show considerable differences in resistance to the disease. About 100 varieties including Ponlai and native types were planted for observations in 1953 and 1954.

The disease is also seed-borne, and seed treatment with chemicals may help reduce its incidence.

4. Elongation Disease

The disease is caused by *Gibberella fujikuroi* (Saw.) Wr. Infected seedlings show abnormal elongation of leaves with light green colour, most conspicuous in the seed bed. Diseased seedlings seldom grow beyond the seedling stage and soon die. The disease is seed-borne and is effectively controlled by seed treatment with organic mercury compounds. While the disease was quite prevalent in the past years, it is no longer a problem since the large scale seed treatment program has been carried on.

B. Insect Pests of Rice

Insect pests cause much damage to the rice crop in Taiwan. The loss is estimated at 15-20 percent of the total production. More than 30 species of insects have been recorded. Major losses are caused by rice

stem borers, rice leaf hoppers, spiny beetles, rice leaf beetles, rice leaf rollers and rice black bugs. Among them the rice stem borers are the most persistent and important. A considerable amount of work has been done in the past few years on the control of these insects. The following are brief accounts on the six groups of major insect pests in Taiwan.

I. Rice Stem Borers

(1) Species and their damage. Three species of rice stem borers are found in Taiwan. They are: *Schoenobius incertellus* Walker, *Chilo simplex* Butler, and *Sesamia inferens* Walker. Of those *Schoenobius incertellus* is the most predominantly important.

Rice stem borers cause severe damage both at the tillering and heading stages of growth. The larvae bore into the young plants and kill the central young leaves and growing points, resulting in a "dead heart" of the plants, which never grow any further but put forth more tillers. The new tillers may be attacked successively and the plants may never head. During the heading stage the borers cut off the basal part of the stalk, causing the death of the entire head, which appears as an empty or "white" ear. Damage in individual fields is often as heavy as 20-40 percent. Fields with 80-90 percent "white ears" have been observed.

The loss from the stem borers in Taiwan is estimated at 10 per cent of the total production for average years – the biggest single enemy of rice production in Taiwan.

(2) Seasonal and regional development. Depending on the temperature of the year, the rice stem borer (*Schoenobius incertellus*) develops 4 or 5 generations in the northern Taiwan and 5 or 6 generations in the South. Each rice crop is subject to the attack of 2 generations of the borers. Because of the warm and dry weather prevailing in the winter, the population in the South is much heavier than that in the North.

On account of the differences in weather conditions and cropping systems, the regional development of the stem borer in Taiwan may fall into three patterns. In northern and central Taiwan, the population of the borer begins to increase in May, reaches the maximum in June, and drops in July when the first crop is harvested. It begins to increase again in August and September and reaches a peak in October. The larvae live over winter in stubbles left after the harvest of the second crop. In the Chiayi-Tainan area in the South, the adult moth may be trapped by light all the year round. It begins to become abundant in February and March, increasing gradually and reaching the maximum in June. In this area, the so-called "intermediate rice crop", which is planted in between the regular first and second crops, offers food to the borers. The population therefore never drops as in other regions but steadily increases to extremely high density until October. The damage from the borers in this region is therefore particularly heavy. After the harvest of the second crop, the population begins to drop. In other areas of the South, the population increases early in

January when a part of the rice crop is already planted, reaching the maximum at the end of May or early June when the crop is mature and partly harvested. The population in July and August is very low, because of the long absence of food supply after the harvest of the first crop. It begins to increase again in September and October but never is as high as in the first crop. In all regions, the different generations of the borers generally over-lap one another and are hardly distinguishable.

(3) Parasites of the stem borers. Two species of larval parasites, *Cremastus shirakii* Sonan and *Horogenes lineatus* Townes et Merino, and three species of egg parasites, *Telenomus dignus* (Gahan), *Trichogramma japonica* Ashmead and *Tetrastichus schoenobii* Ferriere, have been identified recently. Surveys made during the year show the percentage of laval parasites to vary from none in March and April to 15 percent in June and 5–8 percent in other months. *Horogenes lineatus* is more common than *Cremastus shirakii*. The three species of Hymenopterous egg parasites vary from 15 to 45 percent during the year. Among them, *Telenomus dignus* is the most common, being 80 percent of the total. No serious study has yet been made to utilize these parasites in the control of stem borers.

(4) Control measures. Since 1952, many of the newly developed insecticides have been tested and used in Taiwan for the control of stem borers. The first successful test was made in 1952 with "Folidol E–605", an ethyl parathion preparation by Bayer Company of West Germany. In the following year, Endrin also was proved effective. Since then, other preparations of ethyl parathion, methyl parathion, EPN, systox, metasystox, dipterex, chlorothion, diazinon, malathion, gusathion, special emulsified lindane, dieldrin, etc., have been tested. After considering the effectiveness and the degree of toxicity of these chemicals, parathion, endrin, diazinon and gusathion are now recommended for general use.

Field control of stem borers started in 1953. About 3,000 hectares of rice were treated with Folidol for demonstrations. About 30,000 hectares were sprayed by farmers in 1954, and 50,000 hectares in 1955. In 1957, 100,000 to 150,000 hectares may be covered if the insects become as serious as in the past few years.

Information on the development of stem borers is collected for use in the field control program. Studies have been made on rice stuble and light traps. Beginning in December, rice stubble is collected, split and examined at intervals of 10 days until it is plowed under in preparation for planting in the next spring. Number of larvae, number of pupae and number of emerging moths, alive or dead, are recorded. This study gives information on the density of over-winter population, approximate time of moth development in the spring, etc. and serves to forecast the development of the borers. Light traps have been set up in each county to detect the development of the moths throughout the year. Day to

day records are taken and reports are made every 10 days to the authorities concerned. This information is then used to guide the farmers to apply the chemicals at the proper moment. One interesting fact may be mentioned here from the light trap studies. The great majority of the female moths trapped by light have already laid their eggs. This points out the little value of using light-traps as an effective measure for controlling the stem borers in Taiwan.

2. Rice Leaf-hoppers

This group includes two Fulgorids and three Jassids: *Nilaparvata lugens* Stal., *Sogata furcifera* Horvath, *Nephotettix bipunctatus cincticeps* Uhler, *Deltocephalus dorsalis* Motschulsky and *Empoasca subrufa* Melichar. The former three cause more damage to rice in Taiwan than the other two. These leaf-hoppers develop 6 to 10 generations a year in Taiwan and are present all the year round. The population increases in dry seasons, especially during August and September when the temperature is high. The damage is not noticeable when the population is low but is very destructive when the population increases suddenly. The leaves of grown plants may turn yellow and die in large patches. The infestation often occurs in large areas.

These insects can be effectively controlled by dusting 1 percent BHC powder, except *Nephotettix bipuntatus cincticeps* which requires 3 percent. Field control of these insects was started in Taiwan in 1951 together with other rice insects. Recently 3,000-3,500 tons have been used annually.

3. Rice Hispa (spiny) Beetle

The rice Hispa beetle, *Hispa similis* Uhmann, develops three generations in a year in Taiwan. The adult lives over winter among weeds and in soil in uncultivated land. The insect appears first in March, but heavy infestations occur in the second generation during the time when the first crop of rice is approaching maturity and the second crop is just planted. The newly transplanted second crop is severely damaged.

Severe outbreaks occurred during 1951-1953, when the spring seasons were wet. Large scale field control has been practised since then by the use of 10 percent DDT dust or 1 percent BHC dust.

4. Rice Lema Beetle (Leaf-beetle)

The Lema beetle, *Lema oryzae* Kuwayama, has one generation a year. The over-wintered adults begin to appear in February or March, laying their eggs in seed beds or on young rice plants. The larvae live 2-4 weeks, becoming adult in May or June. Then the adult insect begins to hibernate. The damage from the insect usually occurs when the rice plant is still young.

The beetle may be controlled by the use of DDT and BHC dust as mentioned above.

5. Rice Black Bug

The black bug, *Scotinophara lurida* Burmeister, develops 5 generations a year in Taiwan. The adult lives over-winter in

hill-side or uncultivated land. Adult fly around only after dark. The insects live together on the lower part of rice plants near the water-surface in the day time, moving to the upper part in the night.

Considerable damage has been done by the insect in many areas during the past few years. It can be controlled by 1.5 percent BHC dust. Recent studies show that dieldrin controls the insect more effectively.

6. Rice Leaf Rollers

The leaf rollers mentioned here refer to two species, *Cnaphalocrocis medinalis* Guenee and *Parnara guttata* Bremer. They develop 4-6 generations in a year in Taiwan. Rolled or folded leaves are eventually destroyed.

These insects can be controlled by BHC dust.

RICE CULTURE IMPLEMENTS AND FACILITIES IN TAIWAN

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It is often said that, when tillage begins, other arts follow. However, it is the farm implement which started the art of tillage. Farm implements in Taiwan, especially those used for rice culture, are a rich inheritance from the mainland of China. Our statistics show that in Taiwan about 77 percent of the rice culture implements are directly inherited from the China mainland, 15 percent acquired from foreign countries, and about 8 percent developed locally. In this paper, the rice culture implements used in Taiwan will be briefly described according to the sequence of rice growing operations. A summarized report of the recent experiments on the improvement of some of these implements and facilities will also be given.

A. Farm Implements Popularly Used in Rice Culture in Taiwan

I. Implements for Paddy Field Preparations

(1) Plow. As in most of the Oriental countries, there is the time honoured animal drawn plow. The Taiwan plow is always drawn by one animal, never by a team. The indigenous plow is identical to those used in mainland provinces, which belong to the long bottom type. Its total weight ranges from 11 to 16 kg. It plows an average depth of 10 cm. and is not very effective in turning furrow slices. This type of plow can plow about 0.20 ha. per day, and sometime up to 0.30 ha. per day under very favourable conditions. During the Japanese

occupation years, quite a few improved plows were introduced into Taiwan, such as the Isono type, Takakita type, Takechi type, Fukami type, etc. All of them have gone through a mumber of modifications and changes before becoming acceptable to the farmers in Taiwan. Therefore, they are now manufactured in Taiwan to meet the local demand. These improved plows all belong to the short bottom type, and, therefore, are somewhat harder to operate. They weigh from 11 to 26 kg. a piece, will plow an avearage depth of 15 cm., and turn furrow slices better, but their working efficiency per day is about the same as the indigenous plow.

(2) Comb harrow. This is a single row long spike (about 30 cm.) comb shaped harrow and generally has 7 to 13 teeth evenly placed over a working width of 1.2 meters. It is used in the paddy field right after plowing to break the clods and level the land. It can work about one hectare in one day. Bamboo pieces are sometimes fastened to the spikes and make it an almost solid board for moving earth from high spots to depressed spots. A levelling pole may also be attached to the harrow for the final levelling of the paddy field.

(3) Knife tooth harrow. Knife tooth harrows have wooden frames of 35 cm. in length and 1.2 m. to 1.7 m. in width. Their 13 to 19 tooth blades are generally made of cast iron, and are arranged in two rows fixed underneath the frame. In gravelly fields, wrought iron blades are used, and where the soil is very sandy, wooden blades or bamboo blades are also used, though not very popularly. Total weight is around 17 to 19 kg. which is not heavy enough for a good penetration. Therefore, while using the knife tooth harrow in the field, the farmer usually stands on the frame to increase its weight and consequently raise its penetrability and land levelling ability. This harrow can also work one hectare of land in one day.

(4) Paddy field pulverizing roller. This implement not only pulverizes the soil and mixes plant residues into the soil but also performs the field levelling job. Its frame is 60-90 cm. × 1.6-2.7 m. in size, and the roller is usually engraved into seven or eight longitudinal blades of 8 to 10 cm. or so in pitch from a whole piece of timber. Recently iron blades also have been used. The total weight of the roller varies from 26 to 48 kg. This implement is the last one used to complete the paddy field preparations.

(5) Paddy seed bed trowel. This is made of wood, similar to but larger than the mason's trowel. This tool is only used in smoothing paddy seed-beds, but not in big fields.

2. Equipment for Seed Selection and Disinfection

(1) Winnower. Paddy grain that will be used for seed will have to go through the winnower two or three times. The winnower is made of wood. A revolving fan inside is cranked by hand to produce air blast for removing chaff, straw, dust and unripe grains from the good grains. Plain bearings are usually used in the revolving mechanism.

It is only in recent years that ball bearings have been adopted by winnower manufacturers. On an average, 180 hectoliters of paddy may be cleaned by a winnower (on one run basis).

(2) Disinfection tub. It is a common practice in Taiwan for farmers to soak their rice seeds before sowing in a solution of organic mercury compounds for the control of the rice blast disease. Any kind of tub may be used, if it is not inconvenient for such an operation. However, bigger tubs are used because the local farmers' associations usually provide such tubs for public use. Along the side of river streams and near the villages, people usually build disinfection ponds which serve the same purpose.

3. Implements for Seeding and Transplanting

(1) Rice direct planting machine. This machine is of the hill drop type, ordinarily made of sheet metal, and consists of a seed box and, underneath the seed box, 10 to 20 tubing ducts extending to the ground level. It is operated by one person. Check row hills of rice are thus sowed. This machine has amazed the delegates from other countries attending the Far East Seed Improvement Conference held in Taiwan in 1956. However, this is not a very popular machine because the direct planting method is very seldom adopted in Taiwan.

(2) Seedling spade, seedling sickle, seedling stool, seedling board, seedling bucket and carrier, seedling tub, seedling holder. These are used to spade up seedlings from the seed-bed, cut off part of the seedling leaves, arrange seedlings in good order, shake off soil attached to the seedling roots and transport seedings from the nursery to the main field. Their shapes can be visualized from their names.

(3) Check-row spacing marker. The marker is used to enable the farmers to set in seedlings in straight rows and at desired spacing. They are two different types. The rod type, which was originally introduced from Japan, and the disk type, developed in Taiwan. After the disk type marker came on the market, it replaced almost completely the rod type marker. The disk type marker is usually made of wood and has some 13 disks of 18 cm. in diameter evenly spaced on a shaft of 2.8 to 3.0 m. long. (The between disk spaces are usually set at 22 to 24 cm.). This marker has to be run on a well prepared paddy field lengthwise once and crosswise once to form check row marks for transplanting. More farmers use this implement in loamy or a little heavier soil, but less where the field is very sandy, because, on the sandy field, the mark will not show up very clearly. The total weight of the disk type marker is around 11 kg. and its working rate is about 1 ha. per day. Marked rope is also used for check row transplanting, although it is not very popular now.

(4) Transplanting snapper (or thumb protector). It is usually made of sheet copper or bamboo, shaped after the human thumb. The farmer put this gadget on his thumb to separate seedlings into hills and help stick seedlings into the soil.

4. Equipment for Applying Fertilizers and Manure

(1) Fertilizer basket and fertilizer sack. Chemical fertilizers are put into either of these two containers which is hung from the farmer's shoulder by a strap. The farmer takes a handful of the fertilizer from it, and broadcasts it by hand for top dressing.

(2) Manure fork. This tool is used to spread manures on the paddy field before plowing starts, as compost manures are used only for basic application. Since Taiwan is short of steel, most of the forks used come from foreign countries, such as Japan.

5. Weeding and Intertilling Implements

(1) Weed smoother. This is a very old implement popularly used on the mainland, but only in certain localities in South Taiwan. It has a bamboo handle and a wooden board with nail or steel wire spikes underneath. At a glance, it looks like a wide hoe made of wood. With this implement, farmers do not have to kneel down in the paddy field to do weeding. The total weight is about 2 kg. and can weed 1/3 ha. of paddy fields in one day.

(2) Rotary paddy cultivator. This implement was originally imported from Japan, but it is now exclusively made in Taiwan. It has one or two rotors mounted onto a small boat-shaped framework and a handle for the farmer to push. The tilling rotor is about 10 cm. in diameter and 18 cm. in width, and has 15 to 21 teeth which are 5 to 6 cm. long, 2 to 3 cm. wide and usually curved backward. It is now used where the paddy soil is sandy and the paddy rice is planted in check-rows. This cultivator can work 0.3 to 0.4 ha. of paddy fields per day.

6. Irrigation Equipment

(1) Water Wheel. This is a stream-powered type of water lifting equipment, to be used in places where the current of the stream is rapid and strong. Its efficiency is low but since there is no power cost, there are still a few in use in Taiwan. It is generally made of bamboo. The water lifting height is determined by the diameter of the wheel. And the distance between the surface of the stream and the bank is the sole factor that determines the wheel size. One water wheel can ordinarily take care of one hectare.

(2) Dragon pump. This is also another useful piece of equipment with a long history in China. Men step on its pedals to propel a train of water lifting vanes. This equipment can lift water from 0.5 to 3.5 m. high and has a capacity of 25 to 65 m^3. It is usually operated by 2 or 4 people, and 80 to 120 steps per minute is the ordinary speed. It is a very labourious operation. Since the engine-powered centrifugal pumps came to be used in Taiwan, the dragon pump has almost disappeared.

(3) Power pump. Engine or motor powered pumps used in Taiwan are almost exclusively of the centrifugal type. Introduced into Taiwan some 30 years ago, it has been adopted quickly where gravitational irrigation is impossible. Deep water turbine pumps can also be seen in Taiwan, but they are seldom used in paddy fields.

7. Pest and Disease Control Implements

(1) Sprayer. Various types of hand operating sprayers were introduced into Taiwan during the Japanese occupation period. However, it is only during the last five years, that the use of highly poinsonous pesticides have made the sprayer indispensable equipment. With this increasing demand, local machinery works have started manufacturing sprayers. Some are now exported. As the hand sprayer is inefficient, Taiwan farmers now demand power sprayers and 1 to 2 h.p. types are becoming popular among them.

(2) Duster. The hand crank type duster was introduced into Taiwan after the War. It did not become as popular as the sprayer because powder form insecticides can be handled by other simple equipment, or even by the bare hands. A hand operating duster can cover about 0.5 ha. in a day.

(3) Worm scoop, worm catcher, worm comb. These are simple tools farmers can make in their homes to collect worms on leaves before the rice plant starts heading, or to shake insects down to the water to kill them during the growing period. They were used before chemical means of pest control were introduced.

8. Harvesting and Threshing Equipment and Drying Facilities

(1) Sickle. The rice sickle is 10 to 12 cm. along the edge and 2 cm. wide. It is very light in weight, only 0.05 kg. when not fitted with a handle. The handle is made of wood and is about 20 to 30 cm. long. The human arm's pulling force is the only power that makes the sickle cut rice stalks. Therefore, the lighter the weight the better the sickle. One man with a sickle can reap 0.2 ha. of paddy in a day.

(2) Pedal rice thresher. The revolving toothed cylinder type of rice thresher was originally introduced into Taiwan from Japan before the War, but has since been greatly modified by local manufacturers and now only the local products can be seen on the market. A two-man operating thresher can thresh 2,000 to 3,000 kg. of paddy per day. This thresher usually has a grain receiving box and is mounted on sleds so that the whole unit can be towed on the half dried or even wet paddy fields. Since the weather in Taiwan is usually wet in the harvest season, the sequence of the harvesting operations is to reap and thresh right in the field, transport the grain back to the farmstead and then dry and clean the paddy in the courtyard or wherever the drying ground is located.

(3) Rice threshing tub. This is a big round wood tub of 1 to 1.2 m. in diameter and 55 cm. in height. An arched beating ladder (threshing ladder) is placed in the tub for the farmer to beat the rice heads against it. A screen is placed over and around the tub to prevent grains from flying outside the tub. Two men and one tub are capable of threshing about 1,200 kg. of paddy grain in a day. Since the introduction of the pedal rice thresher, threshing tubs have gradually been displaced.

(4) Drying ground. Paddy grains are spread on the drying ground for sun drying. The old fashioned mud drying ground cannot provide a quickly available drying surface after the rain. Therefore, cement drying grounds are adopted by the farmers.

(5) Grain rake, grain sweeper, grain scraper. These are the tools that spread, turn and collect grains during the course of drying on the drying ground. They are exclusively made of wood.

9. Cleaning Equipment and Processing Facilities

(1) Winnower (Already stated in Section 2).

(2) Rice hulling and polishing plant. This equipment is not in the farmers' home, but managed by the local farmers' associations, which are usually located in a village market and render services to all farmers in the area. This type of installation in rural Taiwan usually has a hulling and milling capacity of 2 to 4 tons per hour and requires a prime mover of 7 to 12 h.p.

(3) Rice cleaning sieve. It has a funnel, a framework, and a copper wire screen which is placed at about 36° inclination. It is popularly used for separating brown rice from the paddy after hulling.

(4) Bamboo thread rice sieve, copper wire rice screen. These are usually pan-shaped hand operating equipment used for cleaning purposes.

10. Storage Facilities

(1) Bowl type storage hut. This is for out-door paddy storage. The wall is made of bamboo and adobe; the bottom of wood, and it has a straw thatched top. The total height of this type of hut is 3 m., with a diameter of 2.5 m. The whole structure is lifted 15 to 30 cm. above the ground to keep it dry. Storage capacity per hut ranges from 2,000 to 6,000 kg. of paddy.

(2) Grain storing bamboo bin. This bin is made of bamboo mats and adobe. It is about 2 m. in height, 1 m. in width and 2 to 4 m. in length. It is raised from the ground by legs to keep the stored grain dry.

(3) Grain storing bamboo mat. This is a simple bamboo mat of 5 m. × 2 m. in size. It is rolled up to a convenient diameter, tied with rope and placed on a wooden board to store grains.

(4) Warehouse. The warehouse is operated by the local farmers' association, as mentioned before. It is built of wood or brick walls, wooden or cement floor and tile roof. The usual capacity is 360 metric tons. Paddy is stored in bulk instead of in sacks. Bamboo mats made into chimney like ducts are usually placed in the center for ventilating purposes.

B. Effects Made to Improve Rice Equipment in Taiwan

1. Mechanization of Paddy Farms

In view of the difficulties in increasing the number of draft cattle, the Joint Commission of Rural Reconstruction has been trying for some time to adopt power machinery for rice production. In early 1955, JCRR purchased a Japanese type and an U.S. type power tiller for trying out

purposes. On the strength of the success of the test, 13 more Merry Tillers of 2.5 h.p. each were imported in 1956 and were placed in 13 selected agricultural experiment stations in the Island for the following purposes:

(1) To find out how to utilize power tillers and their attachments under Taiwan conditions; and

(2) To find out the differences in working efficiency and economy between using power tillers and draft cattle.

The tests are necessarily limited to paddy field preparations. The result so far seems to be encouraging, as shown in the following table of comparison on one hectare of land:

	Merry Tiller	*Water Buffalo*
Plowing	18-25 hours	35-50 hours
Pulvertizing and levelling	26-40 ,,	35-50 ,,
Grass reappearing after preparation	in two weeks	in one week
Cost of plowing alone	NT$ 200	NT$ 270

At present about one hundred farmers have purchased the small power tillers and are generally satisfied with their operation. We are now experimenting on the attachments, such as sprayers and threshers, to see how the power of the tiller's engine can be fully utilized. The success of the project depends on the following factors:

(1) Ability to produce locally and cheaply tractor and rotary power tillers;

(2) Further research on the use of power tillers under Taiwan conditions and dissemination of such information among the farmers;

(3) Provision of competent service men and repair facilities at places convenient to the farmers;

(4) Satisfactory fuel supplies; and

(5) Provision of long-term credit at low rate of interest.

2. Improving Animal Drawn Plow

This is a project financed by JCRR and undertaken by the Agricultural Engineering Department of the National Taiwan University. After three years of study, a well balanced and a light plow was developed. This plow has an iron pipe framework and the shape of the share is between that of the western plowshare and the conventional middle pointed oriental plowshare (its point is located about $\frac{1}{4}$ way from landside). Its moldboard is like the western plow but has a very narrow waist due to substantial trimming on its furrow side. This plow also has a convenient depth adjusting device and a breaking pin which helps protect the plow from a sudden and heavy impact, such as hitting a big rock. This plow transmits power better and, therefore, uses the animal power more efficiently and turns the furrow slice better on both paddy field and upland. It is

especially welcomed by the farmer working on heavier soil.

3. Rice Pile Ventilator

In Taiwan, paddy is dried under the sun. The farmers collect the grains together, pile them on higher spots and cover them up with rice straw to wait for the return of the sun. If the wet paddy is piled up long enough, heat will develop and impair its quality. In this connection, a rice pile ventilator was cooperatively developed by JCRR and the Agricultural Engineering Department of the National Taiwan University. It consists of a sheet metal air intake head, a bamboo pipe, and a ʌ-shaped bamboo mat cage. These three parts are secured together, and a bamboo mat is used as a pile bed. The procedure in using this equipment is to place the bamboo mat on a high spot, pile paddy grains on the bed to a depth of about one foot, place the rice pile ventilator in the center, pile paddy grains around the ventilator to the usual height, and cover the pile with rice straw as usually practised. The air which comes n from the ventilator will carry away the heat accumulated in the center through the grain pile.

4. Use of Volcanic Ashes in Building Drying Grounds

A cement drying ground is satisfactory to Taiwan farmers. However, studies have been made on the use of volcanic ash which are produced cheaply and locally to substitute a part of the cement needed. After several trials, it was found that 33 to 35 percent of volcanic ash could be used to substitute the usual cement requirement in 1:4:8 concrete mixture. This type of drying ground will be extended on a large scale this year.

5. Rice Dryer

Three rice dryers of different makes were introduced from the United States for testing. These are a portable rice dryer made by the Behlen Manufacturing Co., a column type rice dryer made by the American Drying Systems Inc., and a small portable rice dryer made by the American Drying Equipment Co. Our preliminary tests have revealed that the Behlen portable dryer has the lowest drying cost, while the other two produce rice of better quality. Farmers are enthusiastic about these artificial dryers. If a rice drying service can be organized with a portable dryer to serve in accordance with rice harvesting time from south to north, the servicing time of the machine in a year may be longer and consequently the cost may be lower.

6. Aluminum Grain Storage Bin

The increased rice production demands more storage space. To meet the demand, silo type round bins of western style were erected. These bins, in most cases, are

erected in groups of three or four, and equipped with a power ventilator so that people can keep the temperature of stored grains down and moisture low. 110 bins were erected, each with a storage capacity of 70 metric tons. To facilitate loading and unloading of these bins, power auger loaders were also distributed with them.

7. Improving Rice Milling Machine

Since germ rice has been promoted by the nutritionists, local machinery manufacturers have started to produce the so-called germ rice milling machines. But their general adoption will be slow in view of the availability of rice mill services throughout the Island.

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Matters Relating to Soil Fertility

10. Summary of the Results from Manurial Trials with all Forms of N, P and K which have been carried out during the last ten years.
11. Effect of Nursery Manuring on the Growth and Yield of Paddy.
12. Analysis of Paddy Soils.
13. Soil Fertility and Future Possibilities of Increasing Yields per Hectare of Rice.

Matters Relating Simultaneously to Rice Breeding, to Soil Fertility and to Soil-Water-Plant Relationships

14. Interaction between Varieties and Fertilizer Response.
15. Field Experimentation:
    (a) Cooperative Variety Trials.
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16. Physiological Diseases and Effects of Elements other than N, P, K and Ca in Rice Culture.
17. Problems of Soil-Water-Plant Relationships in the Production of Rice:
    (a) Country Reports on Recent Research Activities and Results.
    (b) Past and Future Work of the Ad Hoc Working Group on Soil-Water-Plant Relationships.
18. Inter-relationships between various Means of Increasing Rice Production.

Procedural Matters

19. Plans for Future Activities of the Working Parties and the Ad Hoc Working Group.
20. Review and Adoption of the Report.

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